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A new approach for automatic curvature determination from a frontal X-ray image of a scoliotic patient

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Published in:
International Journal of Computer Assisted Radiology and Surgery

IMPORTANT NOTE: You are advised to consult the publisher's version (publisher's PDF) if you wish to cite from it. Please check the document version below.

Document Version
Publisher's PDF, also known as Version of record

Publication date:
2007

[Link to publication in University of Groningen/UMCG research database](#)

Citation for published version (APA):

Sardjono, T. A., Wilkinson, M., Ooyen, P., Veldhuizen, A. G., Purnama, K., & Verkerke, G. J. (2007). A new approach for automatic curvature determination from a frontal X-ray image of a scoliotic patient. *International Journal of Computer Assisted Radiology and Surgery*, 2 suppl 1, S445.

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2. Methods

Since optimal results for vascular segmentation and analysis cannot be achieved by a fully automatic computer algorithm only, we developed a multi-step workflow with the necessity for minimal user input at critical processing steps and the possibility for manual corrections to increase accuracy at the cost of additional time and effort:

- *Preprocessing*: Reduction of image perturbances by adaptive filtering, reducing inhomogeneities and noise while enhancing vascular type structures.
- *Interactive region-growing*: Rough estimation of an initial segmentation mask.
- *Automatic refinement for extraction of peripheral vascular branches*: Vessel leaves are detected by means of graph analysis. Allowing threshold adaption according to local intensity distributions and refinement by a pattern based search algorithm for tubular structures to expand the segmented structures (2D).
- *Semi-automatic refinement by optimal path detection*: Alignment of unconnected vessel parts or extraction of possible vessel paths' by optimal path detection in analogy to a 3D Live-Wire. Costs for path optimization are calculated from image intensities and gradients directly.
- *Vascular tree analysis*: Vessel separation and analysis of vascular branching patterns for liver territory calculations.

3. Results

The presented methods are embedded in a standalone software assistant (MeVisLab prototype) allowing further clinical testing. Processing time for vessel extraction ranges from 1 to 15 min on a standard desktop PC depending on data quality and desired accuracy.

4. Conclusions

The proposed software assistance allows evaluation of hepatic vascular anatomy beyond the diagnostic possibilities offered by standard clinical workstations. Vessels small in diameter or low in contrast are difficult to be examined by direct volume rendering. Therefore further effort for vessel extraction may have an important clinical impact justifying the extra in effort and time for data preparation. Moreover, detailed vascular analysis is a prerequisite for calculation of liver territories, virtual resection planning and computer-assisted risk analysis.

3D reconstruction of the spine from biplanar X-rays using longitudinal and transversal inferences

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Keywords Biplanar X-rays · Spine · 3D reconstruction · Longitudinal inferences

1. Introduction

Biplanar X-rays based methods allow the 3D reconstruction of the spine of patients in standing position with a low radiation dose compared to CT-scan. Nevertheless these methods still require a tedious identification of anatomical landmarks in the radiographic projections. The purpose of this work is to propose an accurate fast 3D reconstruction method of the spine from biplanar X-rays using transversal and longitudinal inferences.

2. Methods

The 3D reconstruction process is composed of four steps:

1. The operator is asked to identify some anatomical elements in the biplanar X-rays.

2. Descriptors parameters of the spine are statistically estimated from the elements identified at the step 1 using a longitudinal inference technique on an in vivo database. A highly detailed ~2,000 points model is then statistically estimated for each vertebra using a transversal inference technique on an in vitro database. This second step provides a first estimate of a parametric model of the spine.
3. The operator is asked to adjust the vertebral position and the shape of the vertebral bodies and pedicles of some vertebrae. As soon as the vertebrae are adjusted, this information is taken into account to statistically improve the whole spine using the longitudinal inference technique.
4. The operator is finally asked to adjust the posterior arch of the vertebrae.

The vertebral shape accuracy was evaluated on 40 thoracic and lumbar vertebrae from 11 patients. Three-dimensional reconstructions from biplanar X-rays (low dose digital X-rays device EOSTM, Biospace med, Paris) were compared to CT-scan 3D reconstructions (1 mm slices). The reconstruction time of the inference method was evaluated on 57 subjects (healthy, moderate and severe scoliosis) reconstructed from biplanar X-rays (EOSTM).

3. Results

The results of the shape accuracy evaluation were: mean value (2RMS) 1.0 mm (2.8 mm) for the whole vertebrae, 0.9 mm (2.6 mm) for the vertebral body + pedicles and 1.1 mm (3.0 mm) for the posterior arch.

The mean reconstruction time for the inference method whole process was 10 min (6–13 min) and was divided by three compared with our previous reconstruction method.

4. Conclusion

The presented method allowed to avoid the tedious identifications of anatomical landmarks in the X-rays thanks to a parametric model using automatic self-correction by longitudinal and transversal inferences which requires only very few adjusting from the operator. This method appears efficient enough for routine clinical use.

A new approach for automatic curvature determination from a frontal X-ray image of a scoliotic patient

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Keywords Deformable model · Charged-particle model · Spine segmentation · X-ray image · Scoliosis

1. Introduction

The determination of the spinal curvature is very important for the orthopaedic surgeon to evaluate curve progression especially for severe cases of scoliosis. For this purpose, the modified charged-particle model (CPM) could give a contribution for determine the curvature. The modified CPM is a new approach of a deformable model based on the CPM. We modified the CPM by putting springs between the positively charged particles to prevent the particles from moving away and to keep the movement of the particles in the appropriate distance without reducing their flexibility. The X-ray image is charged negatively according to the

edge-map or gradient-magnitude image. The particles are attracted towards the contour of the object of interest, because this contour is very dark, thus charged very negatively. The results of the implementation show the effectiveness of the modified CPM for spine segmentation on X-ray images.

2. Methods

A total of 50 frontal X-ray images of scoliotic patients were first improved by morphological image pre-processing methods, especially to eliminate an uneven background, which usually appears on X-ray images and to boost the thoracic part which is less visible due to overprojection of the sternum. Two observers were involved in the manual curvature determination on spinal X-ray images. The equation of the total force for every particle is

$$\begin{aligned}\vec{F}(\vec{r}_i) = & w_1 \vec{F}_c(\vec{r}_i) + w_2 \vec{F}_l(\vec{r}_i) + w_3 \vec{F}_{sh}(\vec{r}_i) + w_4 \vec{F}_{sv}(\vec{r}_i) \\ & + w_5 \vec{F}_{sd}(\vec{r}_i) - \beta \vec{v}_i,\end{aligned}\quad (1)$$

where \vec{F}_c is the Coulomb force, \vec{F}_l is the Lorentz force, \vec{F}_{sh} , \vec{F}_{sv} and \vec{F}_{sd} are the horizontal, vertical and diagonal spring forces. w_1 , w_2 , w_3 , w_4 and w_5 are the weighting factors for Coulomb, Lorentz, horizontal, vertical and diagonal spring forces, and $\beta \vec{v}_i$ is the damping factor or viscous factor. The horizontal, vertical and diagonal spring lengths were automatically determined based on the initial particle position.

3. Results

The inter-observer error in placing manual landmarks is 1.45 pixels. The average error between the particle positions and the manual landmarks on original images is 3.20 pixels. By using the pre-processing method the error was decreased to 2.71.

4. Conclusion

With the modified CPM, the spine segmentation of a spinal X-ray image of a scoliotic patient can be determined, even though there are many cluttered features.

The method of pectus excavatum measurement based on structured light technique: preliminary study

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Keywords Pectus excavatus · Thoracic deformity · Telediagnosics · 3D evaluation

1. Introduction

Pectus excavatum is the most common thoracic wall deformation. The aim of the study was to present recently developed system for chest telediagnostic screening/assessment.

2. Methods

Six patients, males with identified pectus excavatum were examined utilizing Haller (pectus) index and other features of the funnel chest. Deformation and shape of the thorax were measured utilizing new method based on structured light technique with digital sine patterns and Gray codes. Measurement utilizing Algorithms of Directional Merging and Conversion (3D MADMAC) system was used to achieve complete functionality connected with the requirements of posture analysis. Imaging data were prepared for mobile transmission via GPRS/EDGE/UMTS protocol to database.

The pectus excavatum cases were well documented through paired examination of patient pictures and CT scans.

3. Results

Six patients, 16.86 years old averagely, were examined in our preliminary series. The average pectus index was 3.91. Pectus and external thoracic indexes presented tendencies to close correlations.

4. Conclusion

The pilot study depicts new approach to thoracic deformity accurate 3D telediagnostic evaluation utilizing structured light technique. The computer vision system uses the symmetry of fringes analysis (3D MADMAC optometric system). The new concept of chest and posture telescreening not only becomes concurrent to systems mostly based on moiré method but opens the method to cohort, EBM studies.

Development of a computer-aided diagnostic system for Alzheimer's disease using magnetic resonance imaging

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Keywords Computer-aided diagnostic system · Alzheimer's disease · Magnetic resonance imaging · Volumetry · Atrophy · Cortical thickness · Gray matter · White matter · Cerebrospinal fluid · Hippocampus

1. Introduction

Alzheimer's disease (AD) is the most common type of dementia. The purpose of this study was to develop a computer-aided diagnostic system for AD using magnetic resonance imaging (MRI), which is based on automatic volumetry of segmented brain images and generation of three-dimensional cortical thickness images.

2. Methods

A subject's MR image was first matched to the anterior commissure-posterior commissure plane of a digital phantom in standard Montreal Neurological Institute space using the Statistical Parametric Mapping 99 (SPM99) software. Next, the aligned MR image was segmented into the gray matter (GM), white matter (WM), and cerebrospinal fluid (CSF) with SPM99. The intracranial area and hippocampus of the subject were determined using the obtained normalization parameters from a deformed volume of interest (VOI) template, which was defined on a standardized stereotactic space and transformed to the subject's space. The hippocampal volume was obtained from the transformed VOI template. Total intracranial volume (TIV) was measured as summation of the segmented GM, WM, and CSF volumes in the transformed VOI template. Whole brain volume (WBV) was also measured as summation of the segmented GM and WM volumes in the transformed VOI template. The cortical thickness was calculated using an Eulerian partial differential equation (PDE) approach from the segmented GM, WM, and CSF images. The three-dimensional image of the cortical thickness was generated. Prior to clinical application, we investigated the accuracy of the Eulerian PDE approach using numerical phantoms.

3. Results

The TIVs, WBVs and hippocampal volumes obtained by our method correlated well with those measured by the manual method ($r = 0.910, 0.902$, and 0.918 for TIVs, WBVs, and hippocampal volume, respectively). There was an excellent correlation between the actually measured thickness and the thickness calculated using